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REPORT

Aerials for use in television outside broadcasts

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AERIALS FOR USE IN TELEVISION OUTSIDE BROADCASTS

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Summary

The report describes a number of aerials that have been developed for radio links in television outside broadcasts with a portable or mobile camera. The aerials are designed to operate in the upper part of the u.h.f. broadcast band or in the vicinity of 2.5 GHz.

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1. Introduction

When an outdoor event is being televised it may be required to move a camera with the action, to enable the viewer to follow the event in much greater detail. For example, the start of a horse-race is often remote from the grandstand and cannot be seen clearly except from a camera on a vehicle that keeps pace with the horses. Similarly, a camera mounted on a launch following a rowing event can give close-up views of the contestants at any time during the race. Sometimes the scale of the event is sufficiently large to require a camera in a helicopter, at others a man carrying a camera is more appropriate. For all these differing applications the common factor is the radio link needed to pass the video signal from the moving camera back to the outside broadcast control room.

FM links are used with a 16 MHz channel in Band V. The frequency range was originally specified as 580 MHz to 960 MHz. As this is too large a frequency range for simple types of aerial (1.66:1) it was sub-divided into two parts having a small overlap, namely 580 MHz to 780 MHz and 760 MHz to 960 MHz. During the course of the work these frequency ranges were changed to suit the man-pack equipments so that the final frequency ranges were 580 – 720 MHz and 722 – 860 MHz. The greatest relative frequency range is thus 1.24:1.

These frequency bands are shared with u.h.f. television at frequencies below 854 MHz and it is necessary to take account of mutual interference with the broadcast service. At most locations some channels are excluded for this reason and others may be used only with a particular polarization. Thus the link aerials must be available with both horizontal and vertical polarizations. In certain circumstances there may be an advantage in using circular polarization and this also is considered.

Links operating in the 2.5 GHz band use 20 or 30 MHz channels. Both linearly polarized and circularly polarized aerials are in use. In all cases, aerials are required both for the mobile transmitter and for the fixed receiving point.

Some other types of aerials have been produced in previous developments and are mentioned here for completeness. A biconical dipole and a Franklin aerial, both operating in the 2.5 GHz band, were produced for use with a helicopter and vehicle respectively[1]. Both are now used with helicopters. A circularly-polarized yagi or cigar aerial, with circular disc parasitic elements, was produced primarily for electronic news gathering (ENG)[2]. The following sections give a description of various aerials that have been developed more recently, in each case preceded by a summary of the technical performance.

2. Aerials for use with vehicles and launches

2.1. UHF five-element log-periodic aerial

Frequency range : 580 to 900 MHz

Radiation pattern : directional (Fig. 3)

Polarization : vertical or horizontal, adjustable

Frequency, MHz		600	650	750	850	900
Beamwidth	E-plane	±35°	±33°	±27°	±30°	±33°
	H-plane	±63°	±57°	±54°	±55°	±61°
Back/front ratio, dB	E-plane	−18	−32	−21	−29	−23
	H-plane	−24	−27	−21	−32	−22
Maximum Gain*, dB rel. λ/2 dipole		4.8	5.3	5.4	5.2	4.9

Reflection coefficient* ≤ 25%

The aerial was designed using a computer program developed for wideband Band II aerial array designs[3]. The aerial is shown in close up in Fig. 1 and mounted on a rove vehicle in Fig. 2; it may be rotated to give either polarization. It is not practical to steer the aerial on the vehicle and so a horizontal radiation pattern with a broad maximum is required. At the same time the back radiation has to be small to minimise the effects of multipath, which is troublesome at certain locations. Typical horizontal radiation patterns (h.r.p.s) are shown in Fig. 3.

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*Throughout this report the aerial gain is given relative to that of a half-wave dipole and the reflection coefficient applies to an impedance of 50 ohms.

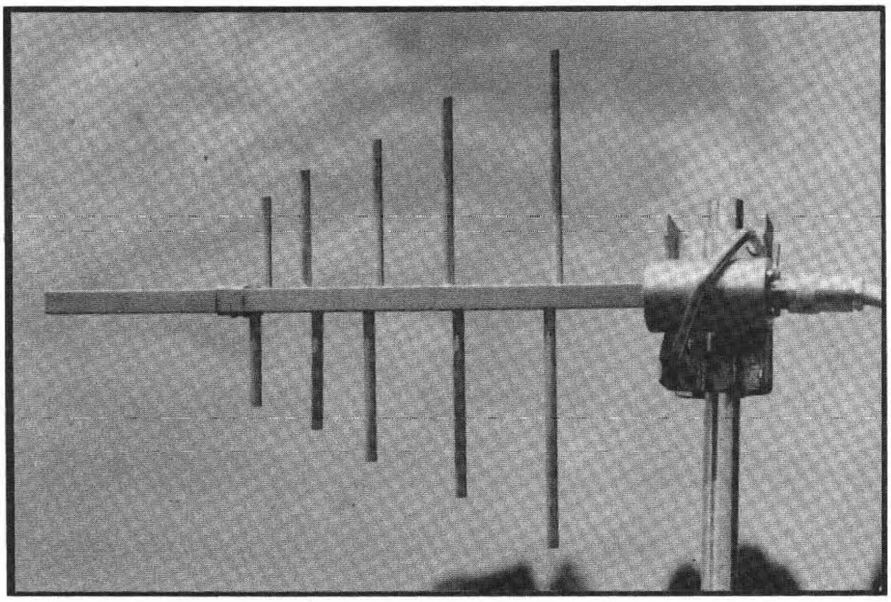

Fig. 1 – Five-element log-periodic aerial.

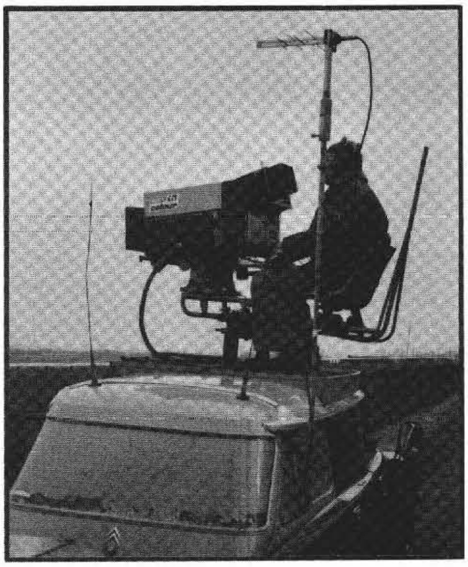

Fig. 2 – Aerial mounted on rove vehicle.

It may be noted that with this design it has been possible to cover both high and low frequency bands with one aerial.

Some consideration was given to the use of a protective cover for the aerial, which could lessen the chance of mechanical damage. Equipment used on outside broadcasts inevitably gets some rough handling and breakages occur. However, a cover would increase the weight of the aerial significantly and necessitate a stouter mounting pole and vehicle attachment. On balance it was thought better to use the aerial without a cover.

2.2. 1.2m (4 ft) Dish and log-periodic aerial feed

Frequency range		580 to 950 MHz		
Radiation pattern		directional (Fig. 5)		
Polarization		vertical or horizontal, adjustable		
Frequency, MHz		650	775	950
Beamwidth	E-plane	±13°	±11°	±9°
	H-plane	±11°	±9°	±6°
First side-lobe level, dB	E-plane	−15.0	−13.0	−10.4
	H-plane	−9.0	−8.0	−6.0
Maximum gain, dB		14.0		15.0
Reflection coefficient	580 – 860 MHz	≤ 25%		
	580 – 950 MHz	≤ 30%		

The five-element log-periodic aerial described in Section 2.1. also provides a suitable feed for a 1.2m (4 ft) dish aerial, although it was found necessary to add a vertex plate to achieve an acceptable impedance match. The combination is used to give a high-gain receiving aerial at a fixed point; it may be used to form the link with a transmitter on a rove vehicle or with a man-pack. Although the arrangement, shown in Fig. 4, may appear more cumbersome than necessary, it uses a standard panning head in common with other equipments and is easy to steer on to a moving transmitter. Typical radiation patterns are given in Fig. 5.

3. Circularly-polarized Band V aerials

3.1. Two-arm log-spiral aerial

Frequency range		580 – 900 MHz		
Radiation pattern		Directional (Fig. 7 (a))		
Polarization		Circular, left-hand		
Frequency, MHz		600	700	860
Beamwidth		80°	80°	82°
Back/front ratio, dB		−21	−24	−29
Axial ratio, dB		1.4	0.8	1.8
Maximum gain, dB		6.4	6.4	6.2
Reflection coefficient	580 – 600 MHz	≤ 25%		
	600 – 900 MHz	≤ 20%		

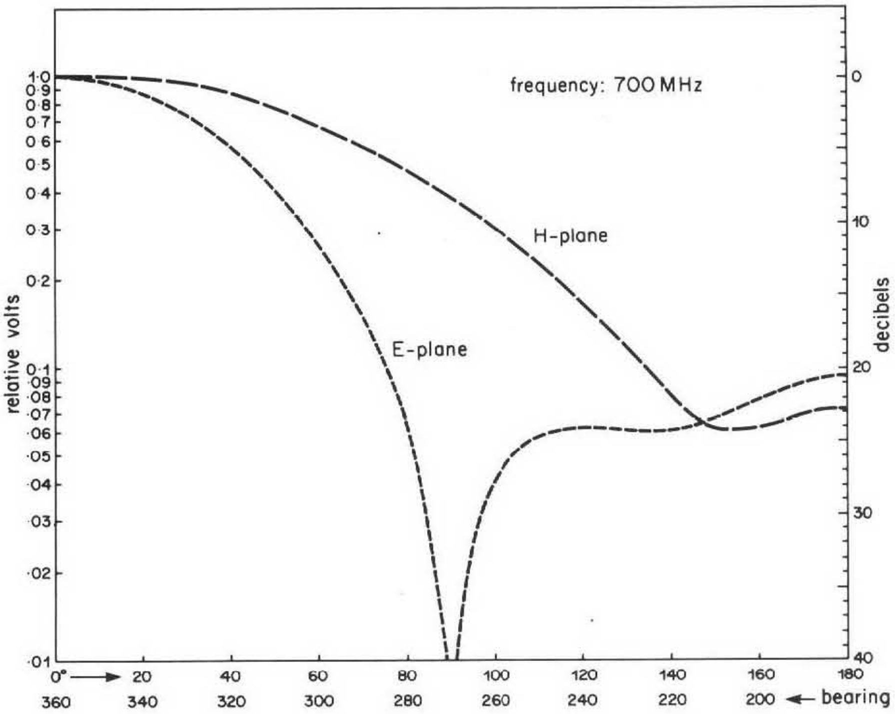

Fig. 3 – Radiation patterns of five-element log-periodic aerial.

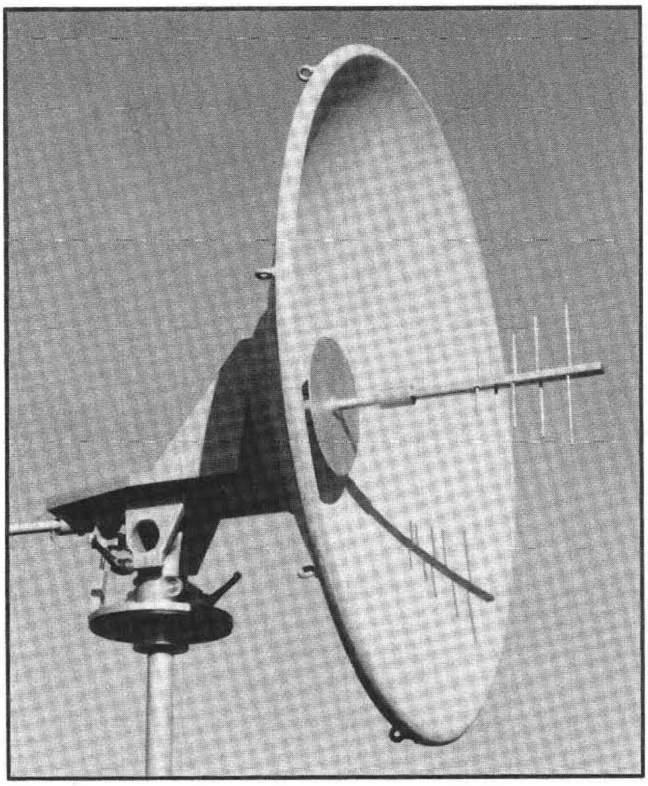

Fig. 4 – 1.2m dish with log-periodic feed and vertex plate.

It was mentioned above that multipath is troublesome on some roves. An example is at Newbury racecourse where there are regularly-spaced trees close behind the path taken by the rove vehicle. The use of the directional aerial described in Section 2.1. is a great help but does not entirely eliminate the problem. A circular-polarized (c.p.) link is often less prone to multipath effects because reflected signals tend to have a sense of rotation opposite to that of the direct signal. They can therefore be at least partially rejected with an appropriate c.p. receiving aerial. For this reason c.p. rove and receiving aerials were requested. One aerial considered for this purpose was a crossed version of that described in Section 2.1. It was constructed by etching the elements on a copper laminate normally used for printed circuit boards. The use of crossed elements led to a change of characteristic impedance for the transmission line from that of the original design and, as a consequence, gave a different performance which was considered suitable only for a dish feed receiving aerial.

For the rove aerial, various configurations of elements were tried in order that an acceptable performance would be obtained from a reasonably compact aerial. The final arrangement was that of the two-arm log-spiral aerial. This was constructed from a p.v.c. cone with the two-arm spiral painted on its surface with silver conductive paint. The arrangement is fed by a balun and matching stubs, co-axial with the spiral elements. The aerial is encapsulated in a polythene road cone and is shown in Fig. 6. A typical horizontal radiation pattern is shown in Fig. 7(a) and a plot showing the variation of axial ratio with azimuth bearing is shown in Fig. 7(b).

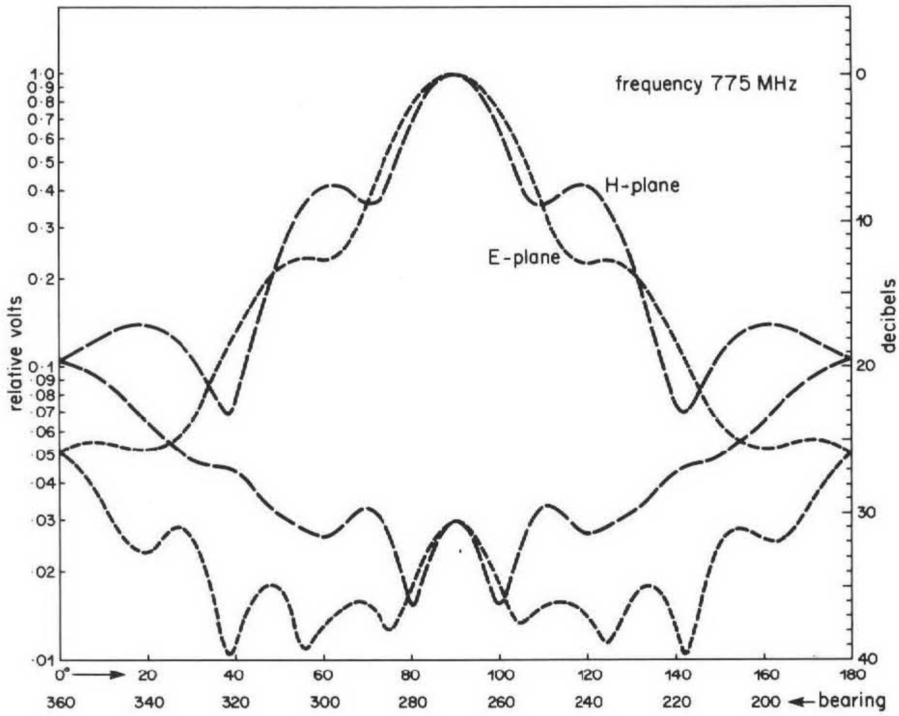

Fig. 5 – Radiation patterns of 1.2m dish with log-periodic feed.

3.2. 1.2m (4 ft) dish with crossed log-periodic aerial feed

Frequency range	: 580 to 860 MHz		
Radiation pattern	: Directional (Fig. 9)		
Polarization	: Circular, left-hand		
Frequency, MHz	: 600	700	860
Beamwidth	: 28°	22°	17°
First side-lobe level, dB	: –23	–19	–16
Maximum gain, dB	: 14.6	15.9	16.5
Axial ratio, dB	: 0.8	1.3	1.8

Reflection coefficient < 20%

This aerial is analogous to the dish with a linearly-polarized feed and is constructed from printed elements on a laminate as described in Section 3.1.

Quadrature drive to the crossed log-periodic arrays is provided by a 0 dB output ratio wireline coupler. As the feed is circularly polarized a vertex plate is not required to correct the aerial input impedance in the presence of the dish. The feed is right-hand circularly polarized, so that the dish and feed combination becomes left-hand circularly polarized. The aerial is shown in Fig. 8 and its radiation patterns in Fig. 9.

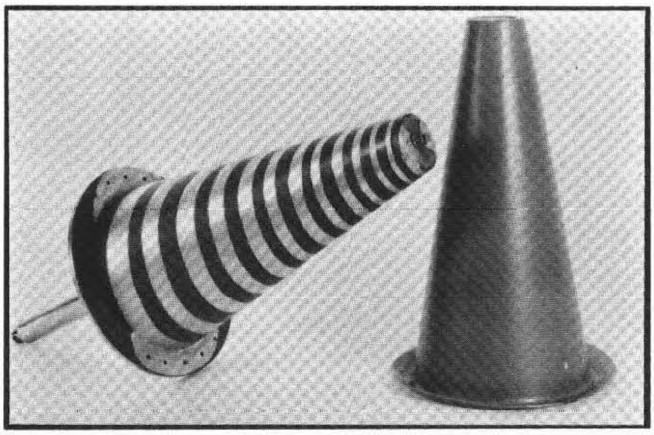

Fig. 6 – Two-arm log-spiral aerial.

4. Aerials for use with man-pack transmitters

4.1. UHF vertically-polarized man-pack aerial

		Low band	High band
Frequency range	:	580 to 780 MHz	720 to 900 MHz

Horizontal radiation pattern : omni-directional

Mean intrinsic gain, dB : 0.0

Reflection coefficient ⩽ 25%

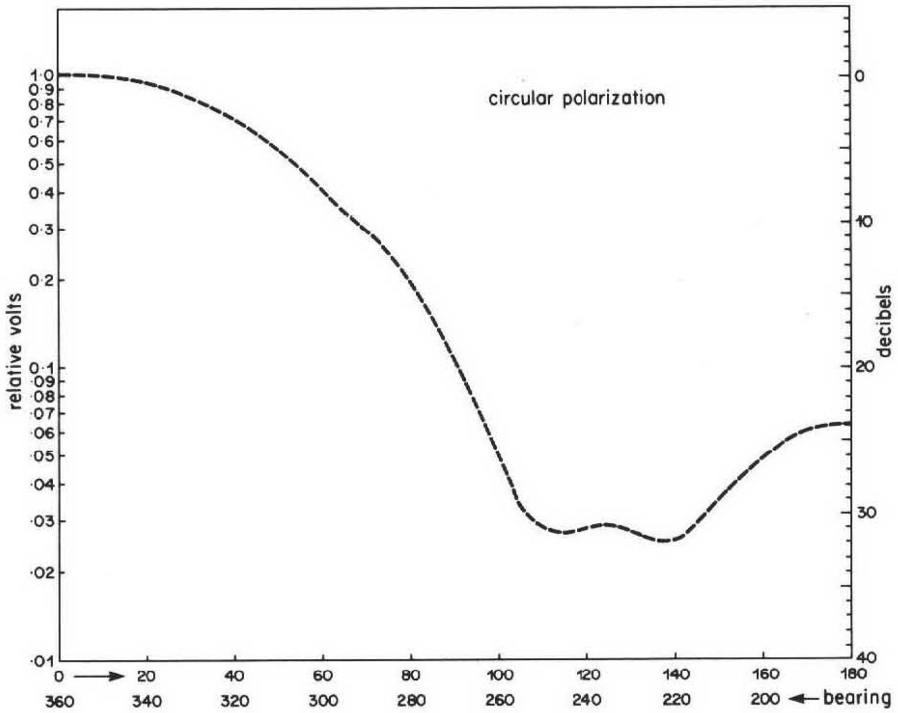

Fig. 7 (a) – Radiation pattern of log-spiral aerial

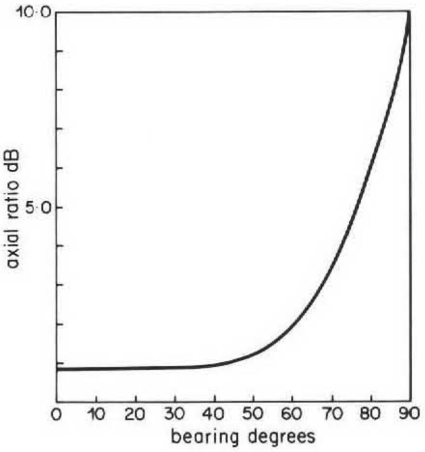

Fig. 7 (b) – Variation of axial ratio of two-arm log-spiral aerial.

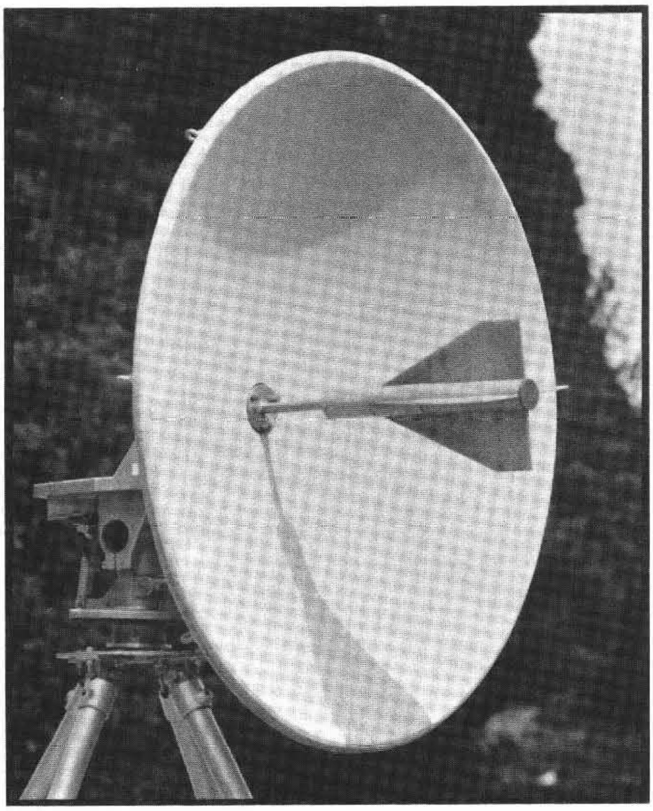

Fig. 8 – 1.2m dish with crossed log-periodic aerial.

The requirement was for a simple and inconspicuous aerial mounted directly on to the man-pack. The aerial for vertical polarization consists of a sleeve dipole with a choke suppressor on its input feeder outer conductor. It is contained in a 25 mm diameter glass-fibre tube which is itself supported by a p.v.c. tube attached to the man-pack. The p.v.c. tube serves to elevate the aerial above the operators head so that the radiation pattern will not be distorted; it also acts as a mechanical fuse, i.e. to break if an excessive bending moment is applied to the aerial. Fig. 10 shows the arrangement.

4.2. UHF horizontally-polarized man-pack aerial

	Low band	High band
Frequency range :	580 to 760 MHz	720 to 860 MHz

Horizontal radiation pattern nominally omni-directional

Frequency, MHz :	570	600	650	700	750	800	850	900
Radiation pattern Max/min ratio, dB								
Low band :	6.0	6.0	5.0	5.0	3.5	5.0		
High band :				6.0	5.5	4.0	4.0	4.5

Mean intrinsic gain, dB: –2.0

Reflection coefficient : Low band {580 – 720 MHz ⩽ 25%
720 – 760 MHz ⩽ 30%
High band 720 – 860 MHz ⩽ 25%

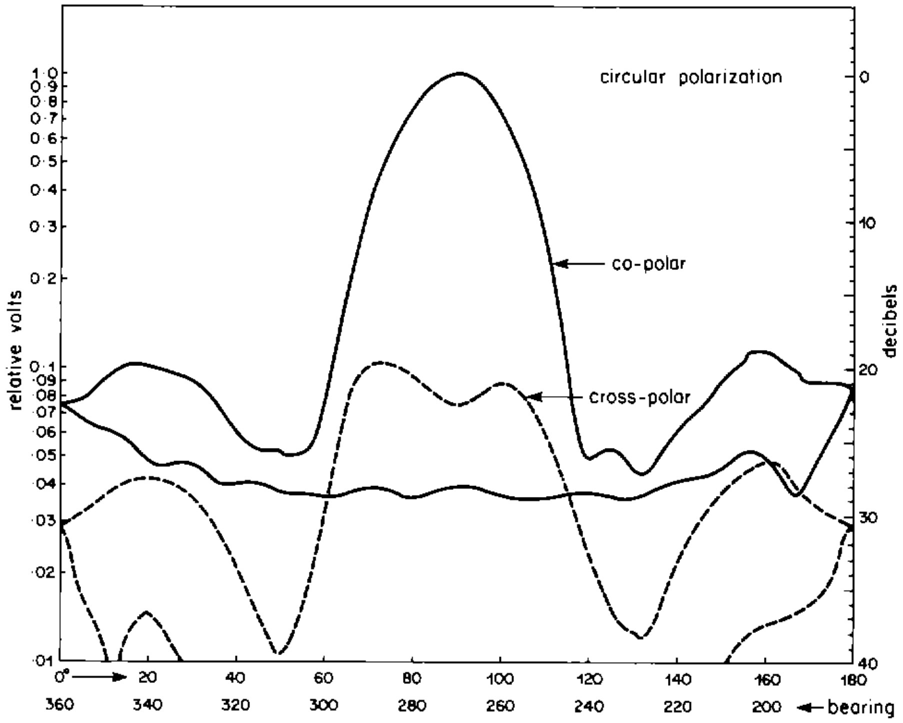

Fig. 9 — Radiation pattern of 1.2m dish with crossed log-periodic feed.

The man-pack aerial for horizontal polarization consists of a pair of orthogonally-mounted monopoles, end-fed from a printed-board balun and matching network. The radiating elements are constructed from stainless steel twin tubes to widen bandwidth. These aerials are mounted in a similar way to the v.p. man-pack aerials. The aerial is shown in Fig. 11 and the horizontal radiation patterns in Fig. 12.

5. Aerials for the 2.5 GHz band

5.1. 2.5 GHz linear polarization feed with 1.2m (4 ft) dish

Frequency range : 2.400 to 2.700 GHz

Polarization : Vertical or horizontal, adjustable

Frequency, GHz	2.400	2.460	2.560	2.660	2.700
H-plane radiation pattern beam width	±3.5°	±3.0°	±2.7°	±2.7°	±3.0°
H-plane first side-lobe level, dB	−20	−20	−17	−18.5	−20

Estimated maximum gain, dB
25.3 dB at 2.460 GHz
25.6 dB at 2.560 GHz
25.9 dB at 2.660 GHz

Reflection coefficient
2.460 to 2.660 GHz ⩽ 20%
2.400 to 2.700 GHz ⩽ 25%

This aerial, shown in Fig. 13, is intended as a replacement for a commercially-manufactured feed aerial having a poor performance at the higher frequencies in the band. Investigation showed that the commercial aerial had a very poor cross-polar performance at the higher frequencies consequent upon the type of balun used. The new design has a wide-band balun and maintains its gain across the frequency band. It is used for point-to-point links and for receiving transmissions from a helicopter. The H-plane radiation pattern is shown in Fig. 14.

5.2. 2.5 GHz linear polarization feed with 0.6m (2 ft) dish

Frequency range : 2.400 to 2.700 GHz

Polarization : vertical or horizontal, adjustable

Frequency, GHz	2.460	2.560	2.660
H-plane r.p. beamwidth	±6.0°	±6.0°	±6.1°
H-plane first side lobe level, dB	−16	−14	−14.5

Estimated maximum gain, dB : 19.5 at 2.560 GHz

Reflection coefficient ⩽ 25%

This aerial is similar to that described in Section 5.1. above. The H-plane radiation

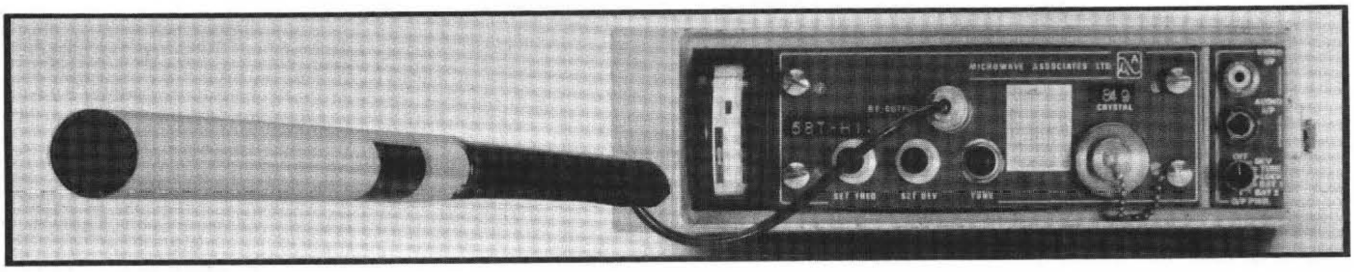

Fig. 10 – Man-pack with vertically-polarized aerial.

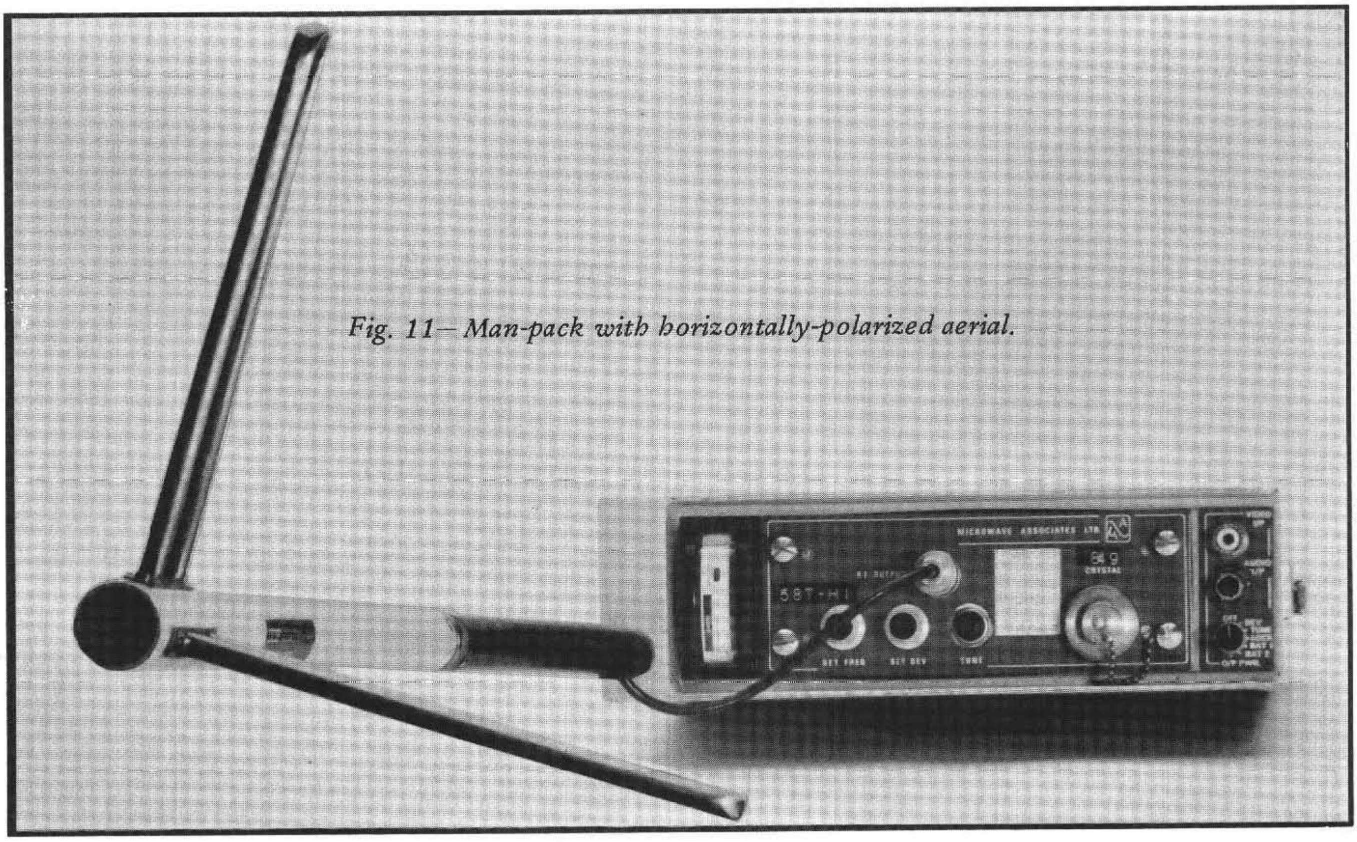

Fig. 11 – Man-pack with horizontally-polarized aerial.

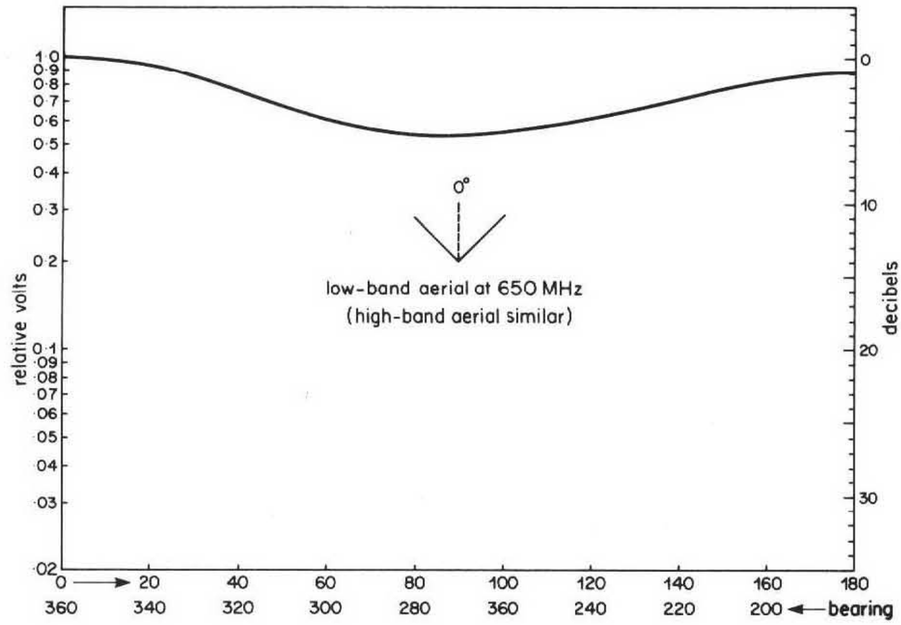

Fig. 12 – Horizontal radiation pattern of h.p. man-pack aerial.

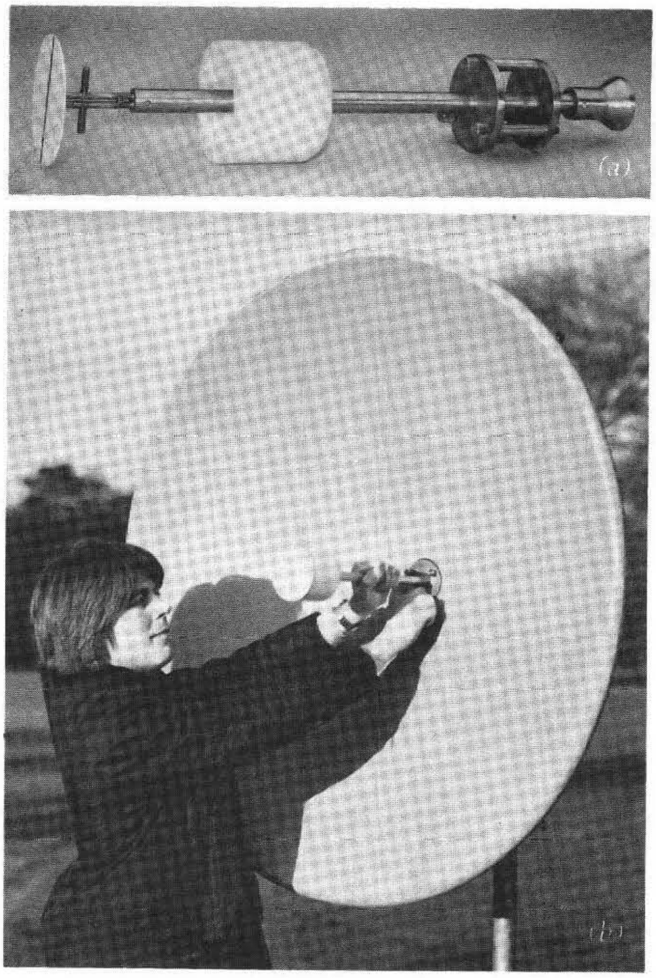

Fig. 13 – 2.5 GHz linear polarization feed,
(a) without cover
(b) assembled on the dish

pattern of the feed with a 0.6m (2 ft) diameter dish is shown in Fig. 15.

5.3. 2.5 GHz circularly-polarized helicopter aerial

Frequency range	: 2.460 to 2.700 GHz
Polarization	: circular, right-hand
Horizontal radiation pattern	: omni-directional
Vertical radiation pattern	: Fig. 18.
Estimated maximum gain, dB	: 1.8
Reflection coefficient	: < 20%

The aerial, shown in Fig. 16, is intended to be an alternative to the linearly-polarized Franklin aerial mentioned in the Introduction. The aerial is shown deployed on an Agusta 109 helicopter in Fig. 17. It was required to transmit on circular polarization for use with some existing commercial receiving equipment, and also to give some radiation vertically downwards – the Franklin aerial has a null in this direction – but very little illumination of the helicopter rotor blades in order to minimize modulation from re-radiation effects. The aerial consists of crossed, bent elements[4] spaced in front of two disc reflectors. The latter are used to prevent excessive sharpening of the downward radiation pattern while maintaining low radiation in the upward direction. Impedance matching is performed within the balun

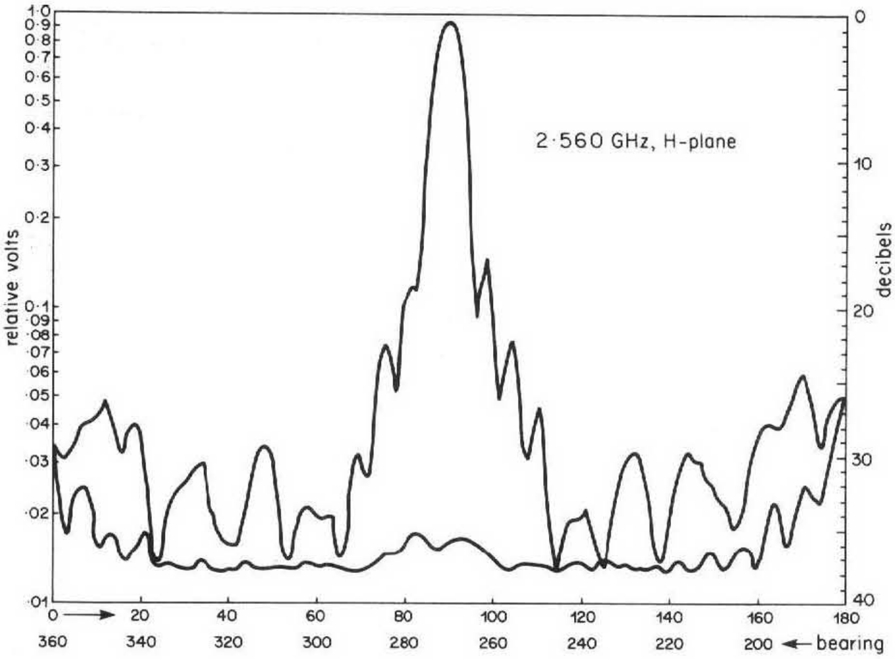

Fig. 14 – Radiation pattern of 2.5 GHz linear polarization feed with 1.2m dish.

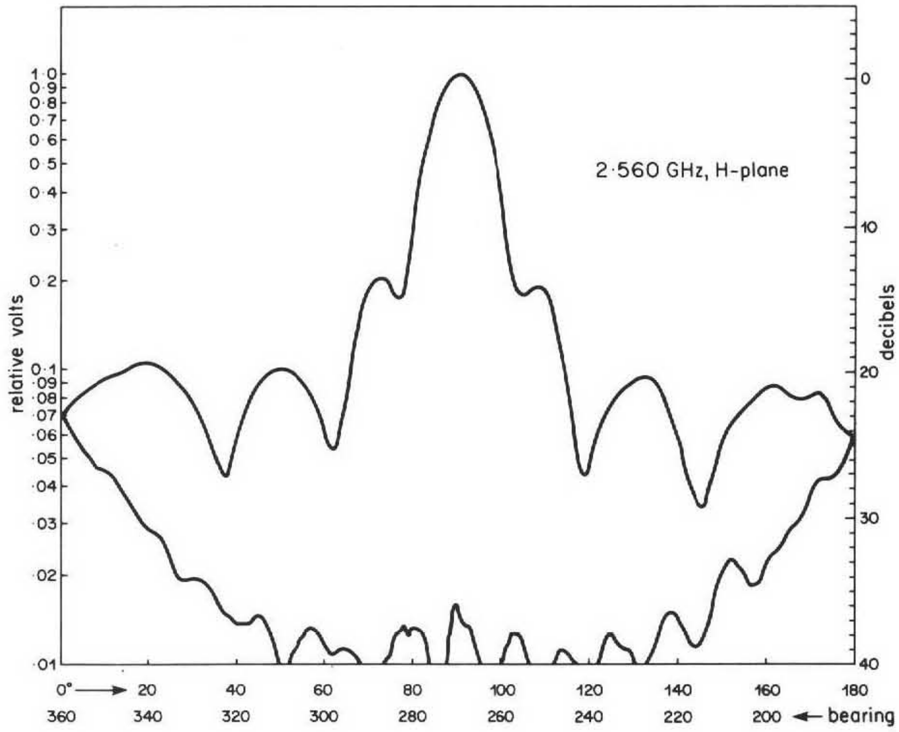

Fig. 15 – Radiation pattern of 2.5 GHz linear polarization feed with 0.6m dish.

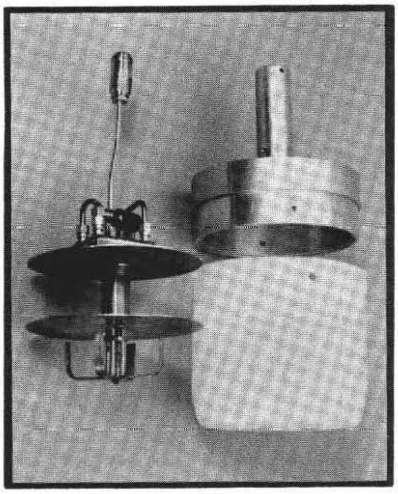

Fig. 16 – 2.5 GHz circular polarization helicopter aerial.

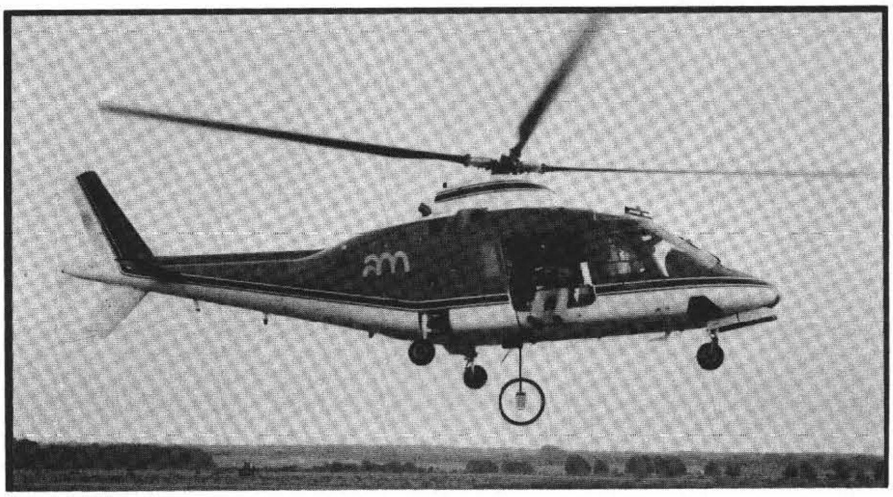

Fig. 17 – The aerial, seen circled here, deployed on a helicopter.

stubs and at the drive point of the elements. Quadrature phase between the two elements is achieved using a wire-line 0 dB output ratio coupler. The vertical radiation pattern is shown in Fig. 18.

6. Conclusions

A comprehensive range of aerials has been produced for use with mobile camera radio links in television outside broadcasting. Some of the designs, in particular the circularly polarized Band V and 2.5 GHz aerials, have not yet been fully evaluated in practical situations and thus the benefits of these designs are not yet known. The remainder are proving to be valuable additions to outside broadcast facilities.

Two of the designs have been licensed for commercial exploitation.

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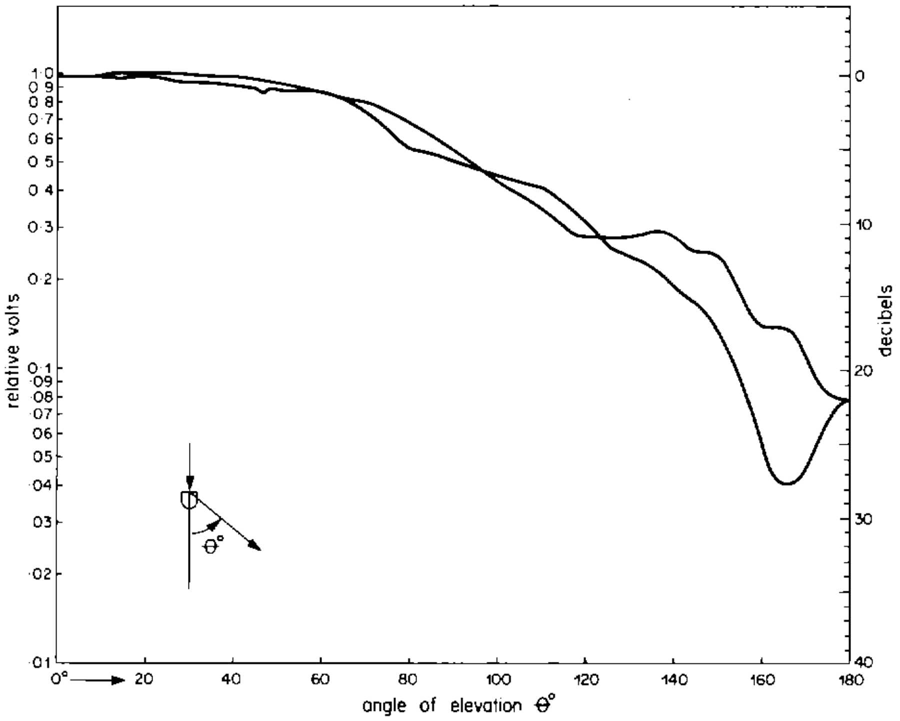

Fig. 18 — Vertical radiation pattern of 2.5 GHz circular polarization belicopter aerial.

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